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Ontario Geological Survey
Open File Report 6179

Aqua Regia, Mobile Metal Ions and Enzyme Leach[SM] Soil Geochemical Survey Results from the Timmins Area: Discover Abitibi Initiative

2006

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ONTARIO GEOLOGICAL SURVEY

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Aqua Regia, Mobile Metal Ions and Enzyme Leach[SM] Soil Geochemical Survey Results from the Timmins Area: Discover Abitibi Initiative

by

M.A. Fedikow

2006

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A project of innovation, cooperation and revitalization

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Un projet d'innovation, de coopération et de renouvellement

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Miscellaneous Release—Data 200

Soil Geochemical Data (Aqua Regia, Mobile Metal Ions and Enzyme Leach[SM]) from 8 Transects in the Timmins Area: Discover Abitibi Initiative

by M.A.F. Fedikow

This digital data release contains aqua regia (UT-1), Mobile Metal Ions (MMI) and Enhanced Enzyme Leach[SM] (EEL) analytical data for sample localities from 8 transects in the Timmins area described in Open File Report 6179. Other information provided includes sampling site locations, sample descriptions and sampling protocols. Samples were analyzed using three separate analytical protocols including two proprietary extractions (Mobile Metal Ions and Enzyme Leach[SM]) and one strong partial digestion (aqua regia). Results are described for each transect and based on the magnitude and number of samples defining the observed Au anomalies, the transects are ranked for exploration follow-up. The data are available as Microsoft® Excel (.xls) files on 1 CD-ROM.

This CD-ROM is available separately from the report.

Abstract

The collection of 916 soil samples and analysis using 3 analytical protocols (Mobile Metal Ion Technology® (MMI), Enhanced Enzyme Leach℠ (EEL) and an aqua regia digest (UT-1)) has successfully delineated single to multiple sample, low- to high-contrast gold anomalies. Soils were collected along 8 transects in the Timmins area, at depths between 10 and 25 cm below the point at which soil formation was initiated. The gold anomalies vary in width from 25 m to several hundred metres along the individual transects. Their definition is based primarily on MMI and EEL extractions, but these anomalies are also often associated with or encapsulated by areally extensive gold anomalies based on UT-1. It is suggested the aqua regia digests reflect the presence of glacially transported detritus enriched in gold and derived from a mineralized source region exposed and abraded during glaciation. The results for the Matachewan and Hislop transects are ranked as being the most significant in terms of the magnitude of the gold anomalies and also the number of samples that comprise these anomalies. The materials sampled for this survey and the depth of sample collection are deemed to be appropriate for use in future geochemical surveys.

Aqua Regia, Mobile Metal Ions and Enzyme Leach[SM] Soil Geochemical Survey Results from the Timmins Area: Discover Abitibi Initiative

M.A.F. Fedikow[1]
Ontario Geological Survey
Open File Report 6179
2006

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Introduction

The exploitation of mineral commodities in the near-surface geological environment has become increasingly difficult due to the exhaustion of mineralization exposed at surface and the mantling of prospective bedrock by glacially transported till and its derivatives. Thick glaciofluvial and glaciolacustrine sediments topped by organic deposits make mineral exploration in these terrains challenging. For this reason, a plethora of innovative geochemical exploration techniques using selective and partial digestions, coupled with state-of-the-art instrumentation capable of measuring concentrations in the parts per billion (ppb) and sub parts per billion range, have been developed. These techniques offer the explorationist tools to "see through" overburden and derive useful mineral exploration data for integration with geology and geophysics and ultimately for drill testing multivariate anomalies. The techniques will identify subtle geochemical signatures related to buried and/or blind mineralization which result from the migration of ions from source to surface soils. The ions then become lodged at a specific depth in the soil profile. Mineralization buried at depths of up to 800 m has been identified using these techniques. The stronger digestions, such as aqua regia, are more adept at approximating the bulk composition of the soil. This is more likely to document the presence of *in situ* bedrock or transported base and precious metal signatures resulting from erosion of mineralization and bedrock during glaciation.

The proprietary Mobile Metal Ions Process® (MMI) partial extraction has been utilized worldwide on a wide range of commodity types from base and precious metals to diamonds. The Process® is based upon proprietary partial extraction techniques, specific combinations of ligands to keep metals in solution, and relies on strict adherence to sampling protocols usually established during an orientation program. Geochemical data resulting from MMI analysis of improperly collected soils cannot be ameliorated with univariate and/or multivariate statistical and graphical solutions. The MMI-M leachant solution was used in the MMI extraction of the soils sampled in this survey.

The Enzyme Leach℠ is also a proprietary "selective" digestion and has been applied to a wide range of commodities in diverse geological and climatic environments. The "enhanced" version of the enzyme leach, Enhanced Enzyme Leach℠ (EEL) was used in this survey, and like the "standard" grade of enzyme leach, the method targets amorphous manganese dioxide coatings on individual soil particles. These coatings are the interpreted residence sites of ions originating from a source region at depth.

The inclusion of a "traditional" soil geochemical technique in the survey was accomplished using "Ultra-Trace 1" (UT-1), an aqua regia technique based on the analysis of a 0.5 g sample.

The recognition of anomalies in geochemical data has progressed from simple visual inspection in small data sets to multivariate, parametric and nonparametric or robust statistical methods for large data sets usually extracted from regional geochemical surveys. Derived parameters from these statistical exercises, such as factor scores or discriminant functions, have been successfully utilized in reducing a large number of potentially useful variables to a select few variables that identify and localize anomalous geochemical signatures. These statistical approaches have been required to manipulate accurate and precise, low-cost, multielement geochemical data.

The MMI and EEL technologies as well as the UT-1 aqua regia digestion in combination with inductively coupled plasma mass spectrometry (ICP–MS) analytical instrumentation are capable of analyzing soil samples at parts per billion and sub parts per billion concentrations. The resulting analytical databases comprise a multielement suite that reports analyses for base and precious metals, pathfinder elements for these commodities, as well as elements useful for mapping bedrock geology obscured by glacial overburden and its derivatives. The large number of elements in the database provides an

opportunity to assess an area of interest for a wide range of metallic mineral deposits with only minor drawbacks in terms of lower limits of determination.

The results of the application of these techniques to 8 sampling transects in the Timmins area is described below.

Terms of Reference

Mount Morgan Resources Ltd. and Watts, Griffis and McOuat Limited were contracted by the Timmins Economic Development Corporation, and its agent Mr. Robert Calhoun, to provide the framework for the sampling, analysis and interpretation of the survey. The sampling was initiated after an introduction to the survey areas by Mr. Calhoun and completed in a term of 20 days in November 2005. Samples were sent to SGS Laboratories (SGS, Toronto, Ontario) for MMI analysis and to Activation Laboratories Ltd. (Actlabs, Ancaster, Ontario) for EEL and UT-1 digests. The analytical data were received from the laboratories late in December of 2005. Interpretation of the analytical data is limited to the element gold (Au) by the terms of the contract. The interpretation of the remainder of the data will be undertaken under a subsequent contract.

Purpose of the Survey

The soil geochemical surveys undertaken in the Timmins area is intended to assess each of these 3 analytical protocols for their applicability to the challenging overburden conditions characteristic of the Timmins area. It is believed that this project will identify the sampling and analytical strategies that will provide enhanced opportunities for mineral exploration in the area.

This survey was conducted as part of the Discover Abitibi Initiative. The Discover Abitibi Initiative is a regional, cluster economic development project based on geoscientific investigations of the western Abitibi greenstone belt. The initiative, centred on the Kirkland Lake and Timmins mining camps, will complete 19 projects developed and directed by the local stakeholders. FedNor, Northern Ontario Heritage Fund Corporation, municipalities and private sector investors have provided the funding for the initiative.

Location of the Survey Areas

The location of the 8 individual survey areas are depicted in Figure 1 and are also shown, overlain on the regional geological setting for the Timmins area, in Figure 2. The location of each transect was predetermined by the exploration companies participating in the Soil Geochemistry Project of the Discover Abitibi Initiative.

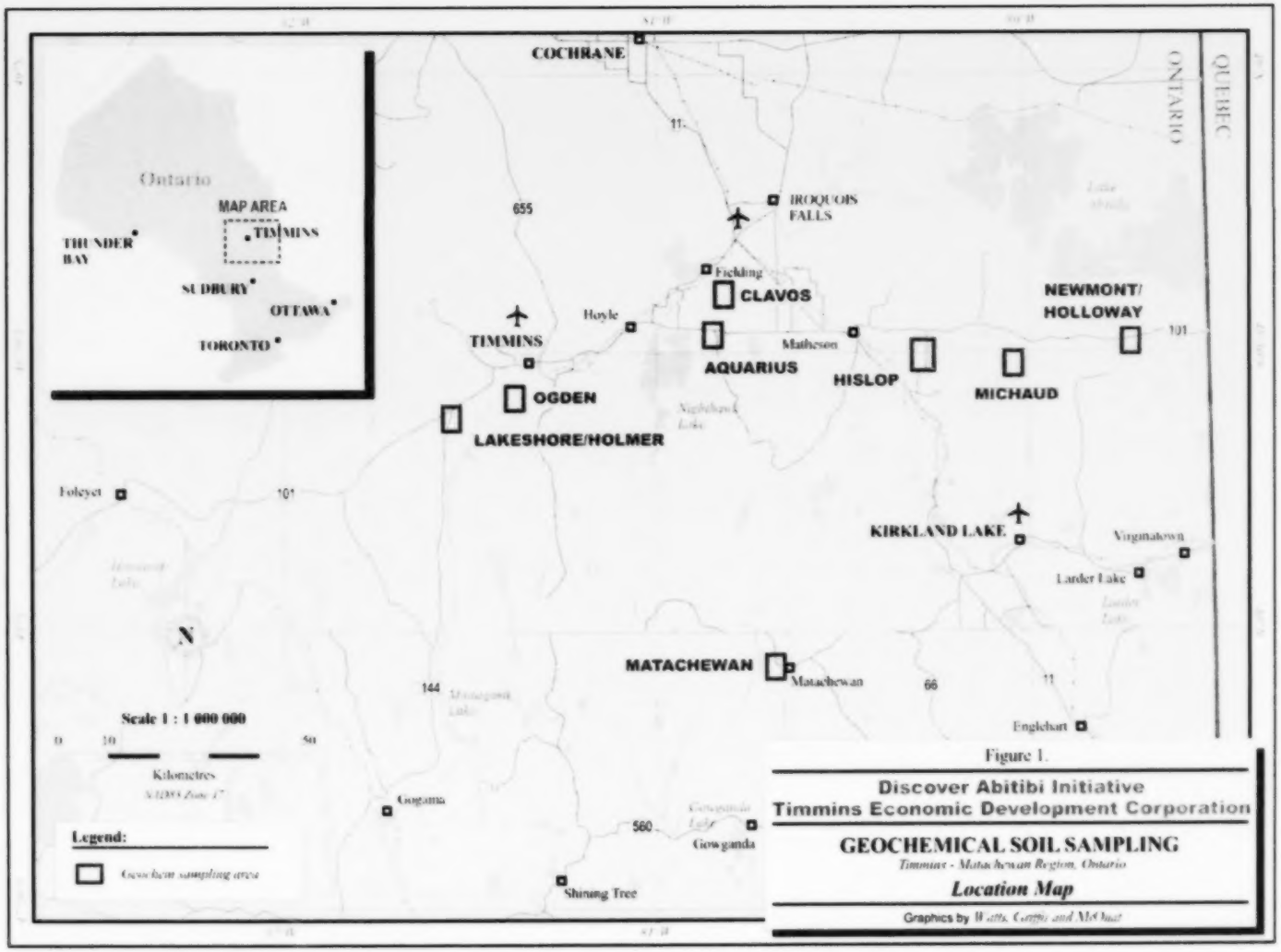

Figure 1. Locations of the 8 survey areas in the soil geochemical survey of the Timmins area.

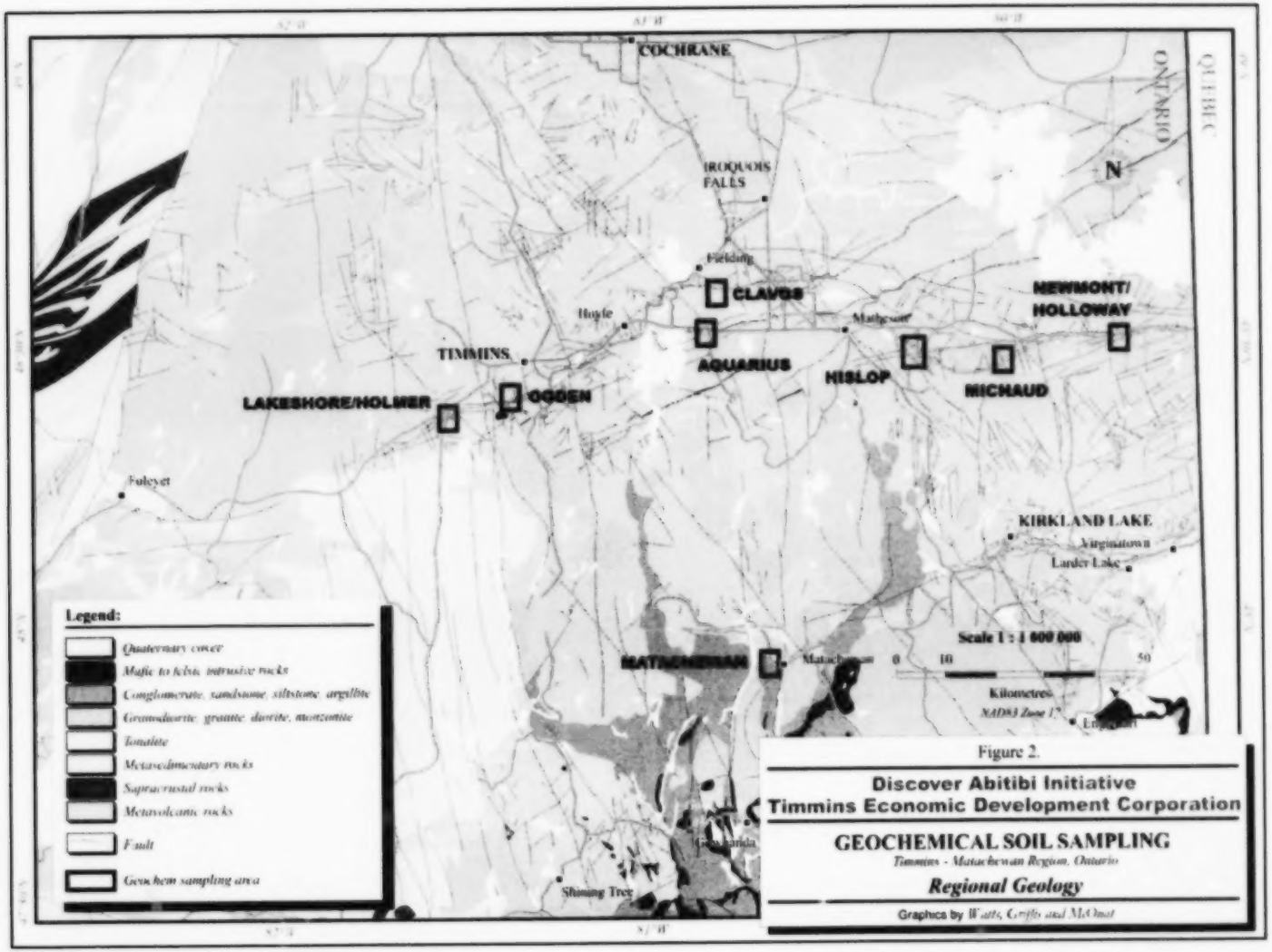

Figure 2. Locations of the 8 survey areas as related to the regional geology in the soil geochemical survey of the Timmins area.

Sample Collection and Analysis

Sample collection for this survey followed the general approaches established as a result of numerous case histories and research-oriented studies. These studies established optimum depths of sampling and preferred locations of high-contrast residence sites in the soil profile and these protocols are described briefly here. Additional information is available from the MMI (www.mmigeochem.com) and the Activation Laboratories (www.actlabs.com) Web sites [both accessed March 10, 2006].

Samples of silt-clay-sand-rich soil, each weighing approximately 250 grams, are normally collected at station spacings of 25 m in precious metal exploration and up to 50 m in the case of base metals. Ziploc® or snap seal plastic bags are ideal for this purpose. Sample spacing should be established on the basis of a "best-estimate" of the likely target being sought with estimates from historical data or exploration results from nearby programs. Sample locations are documented according to grid coordinates and with global positioning system (GPS) readings at each station. Samples are normally collected from a consistent depth of 10 to 25 cm beneath the point at which soil formation is initiated in the particular landscape environment where the survey is taking place. The depth of sample collection and the targeting of high-contrast base and precious metal residence sites may be different than that utilized for this survey although this can only be determined by an orientation survey based on a program of vertical profiling. No such program of vertical profiling was undertaken prior to this survey. Samples are normally collected with a stiff vinyl trowel after the initial sample pit was dug with a shovel. The shovel is clean without paint or rust. In particularly challenging overburden scenarios where a significant thickness of organic soils is encountered, samples may be collected with an auger. A Dutch auger was found to be particularly useful for this purpose. Samples are bagged on site without preparation and were shipped to SGS Laboratories (SGS, Toronto, Ontario) for MMI analysis and to Activation Laboratories Ltd. (Actlabs, Ancaster, Ontario) for EEL and UT-1 digests. Final analysis was carried out ICP-MS.

The soil samples submitted for analysis included field duplicates. Analytical duplicates and standard reference materials (SRMs) were utilized by SGS and Actlabs to monitor analytical accuracy and precision. These results were also reported with the analyses. All samples were a mixture of sand-silt and clay in varying proportions. Field duplicates were collected from a separate sample site approximately 1 m from the initial sample site in exactly the same manner as the initial sample.

For MMI analysis, a 50 g aliquot is removed from the sample bag and mixed with 50 mL of dissolution. No sample preparation (sieving or drying) is performed on the sample once it leaves the field. The EEL approach requires that the sample be dried at a temperature not exceeding 40°C and then disaggregated and sieved to –60 mesh. For aqua regia analysis, the sample is dried at 60°C and then sieved to –80 mesh.

Data Treatment and Presentation

The analytical data were examined visually for results that were less than the lower limit of determination (<LLD) for ICP-MS. The data with <LLD were replaced with a value one-half of the LLD for statistical calculations and graphical representation. The 25th percentile and the arithmetic mean of the lower quartile for the data were used to normalize all analyses and was determined using the software program SYSTAT® (V10). The response ratio (RR) was calculated by dividing the analytical value for the element at each site with the arithmetic mean of the lower quartile. The response ratios were utilized in plots. Zeros resulting from this calculation are replaced with "1". Response ratios are a simple way to compare

the data collected from the 8 different sampling transects. This normalized approach also significantly removes or "smoothes" analytical variability due to inconsistent dissolution or instrument instability. For the Timmins data set, the values for the 25th percentile and background were determined to be 0.05 ppb Au for MMI and 0.0025 ppb Au for both EEL and UT-1. Analytical data and quality assurance–quality control (QA-QC) are presented in MRD 200, in Appendixes 1 through 3 for each of the analytical protocols.

Response ratios from the 8 sampling transects in this survey are presented as individual element (AuRR) bar charts. This simple and straightforward profile permits the identification of anomalous responses along the transect and also allows comparison between analytical protocols when the profiles are stacked. These results are presented in Figures 3 through 10. The data used to generate all figure plots are available in MRD 200, in Appendix 4, along with the figures.

Results

QUALITY ASSURANCE AND QUALITY CONTROL

The results of AuRR analytical duplicates for each of the 3 analytical protocols are basically good. The analyses of samples by MMI exhibit excellent reproducibility across a wide range of concentrations, although similar to the EEL and UT-1 data, many of the duplicate pairs are <LLD. A single sample pair analyzed with the MMI Process® reported 0.1 and 0.6 ppb Au, respectively. The EEL analytical duplicates are primarily <LLD; although analyses with values greater than 0.3 ppb Au appear to be reproducible, whereas analyses with values less than 0.3 ppb Au are not. A similar observation was made for the aqua regia analyses. A single duplicate pair with 117 ppb and 33.4 ppb Au suggests that there may be sample inhomogeneities related to specific gravity (sulphide minerals, native gold) in this particular sample.

Field duplicates are difficult to assess due to the predominance of <LLD responses in all 3 protocols. The MMI data performed well in this regard with excellent reproducibility at low concentration levels of less than 0.4 ppb Au. All but one EEL duplicate pair were <LLD, although the single reporting sample had field duplicates of 0.005 ppb Au and 0.008 ppb Au. All aqua regia field duplicates were <LLD for Au.

The accuracy and reproducibility of the SRMs varied considerably among the 3 analytical approaches. Excellent results were obtained from 20 replicate analyses of the standard reference material MMISRM14 (with a certified value of 44.1 ppb Au) for MMI. There were no certified values for Au in the standards selected for use in the EEL and the results for UT-1 were poor at best. The four duplicate analyses of reference materials analyzed by UT-1 gave the following measured responses and certificate values, respectively:

GXR-1: 3300 ppb and 3300 ppb
GXR-2: 68.9 ppb and 36 ppb
GXR-4: 280 ppb and 470 ppb
GXR-6: 55.2 ppb and 95 ppb

These results suggest accurate and reproducible Au analyses at high concentration levels but of lower quality when Au contents are less than 500 ppb.

No evidence of laboratory contamination with respect to Au was observed in most of the blanks analyzed by the 3 protocols; 2 of 20 MMI blanks reported 0.1 ppb Au.

The variability in the Au analyses of field duplicate pairs may be related to the inclusion of organic matter in either of the samples. Unless care is exercised in the collection of the duplicate samples, significant variance can occur. This variability is compounded when samples are collected with an auger in deep organic terrain, as it is very difficult to ascertain with any degree of certainty the exact depth from which both samples were collected.

The failure to produce accurate and reproducible analyses in SRMs is more serious and indicates that a review of sampling and analytical protocols when working with these standards is necessary. This is suggested by the aqua regia (UT-1) results.

DATA DESCRIPTION

The diagnostic signal of a significantly mineralized zone will produce moderate- to high-contrast apical responses over the target based upon either the MMI or EEL analytical approach; however, away from the mineralization at "background" locations, there may be no trace of the presence of a specific metal in the analysis. This must be considered when working with selective or partial extraction technologies. The presence of significant numbers of elements <LLD does not indicate that the particular extraction is not working or has been "buffered" by soil composition. Both the MMI and EEL processes are designed to extract only metals from the soil that are moving from source to surface and characteristically report metal contents in low ppb concentrations. Away from a buried or blind source region, there will be minimal if any geochemical signal.

In the MMI and EEL data, this is exactly the case. There are excellent examples in the AuRR data along the 8 sampling transects where Au anomalies are not present, whereas high-contrast Au responses are present along others. Areas of no AuRR anomalous response are often characterized by AuRR of 1 indicating that the original analysis was <LLD.

METHOD OF INTERPRETATION

Multivariate statistical and graphical techniques were not utilized for the interpretation of geochemical data in the Discover Abitibi geochemical survey. This is because in this initial interpretation only Au is being considered. A simple visual and graphical approach was used for the interpretation of the data. Subsequent to the calculation and plotting of response ratios, the plots are examined for anomalous values (as spikes) or groups of elevated responses for Au. Groupings of elevated AuRR along the transect have relevance to underlying geological conditions and their contained mineralization. Generally, a response ratio less than or equal to 20 times the background is an initial indication of a low-contrast anomalous response, although this "threshold" is not universal. A response ratio between 20 and 50 is used to indicate a moderate-contrast anomalous response and values greater than 50 are referred to as high-contrast. Often, pattern recognition in the interpretation of geochemical data is paramount.

GEOCHEMICAL RESPONSES ON THE SAMPLING TRANSECTS PROFILE LINES

The nature of the AuRR along each of the 8 sampling profile lines is described below. The geochemical narrative is graphically depicted in the associated figures. Sampling locations are provided as station numbers, north and south along the transect (e.g., 2200N, 450S).

Aquarius Transect Profile Line 139E

Results for the analysis of soils from this transect (*see* Figure 3) are disappointingly low for both MMI and EEL data. The MMI data have a range in AuRR of 1 to 8 and the EEL data are all AuRR=1. These responses are interpreted to represent random background variation. There are 2 high-contrast but single-sample responses for Au in the aqua regia data. An AuRR of 13 720 occurs at station 2200N and a lower AuRR of 52 at station 4575N. These responses are not related to one another and are the only elevated AuRR in the UT-1 data.

The absence of MMI and EEL AuRR anomalies are indicative of the absence of any significant bedrock-hosted source of Au in the area crosscut by the transect. The UT-1 results suggest the presence of particulate Au in the soil at the 2 named locations. These responses may be reflecting glacially transported Au particles associated with sulphide minerals. This is considered likely for the response of 13 720 times background.

Clavos Transect Profile Line 300W

The Clavos results (*see* Figure 4) are marginally better than those for the Aquarius transect for the MMI and EEL data. In the MMI responses, there are 2 low- to moderate-contrast, single-sample AuRR responses of 14 and 28 between 100N and 50N, respectively. The range of AuRR responses is 4 to 28 and there are no associated elevated AuRR with these two areas. The EEL data records a single sample high-contrast AuRR of 424 at 25S on the transect. There are no other anomalous responses on the line and this anomaly should be regarded as a possible signal from a narrow gold-mineralized zone. There is no corresponding MMI AuRR anomaly at this site. The results of the UT-1 analyses indicate all responses have background values of AuRR of 1.

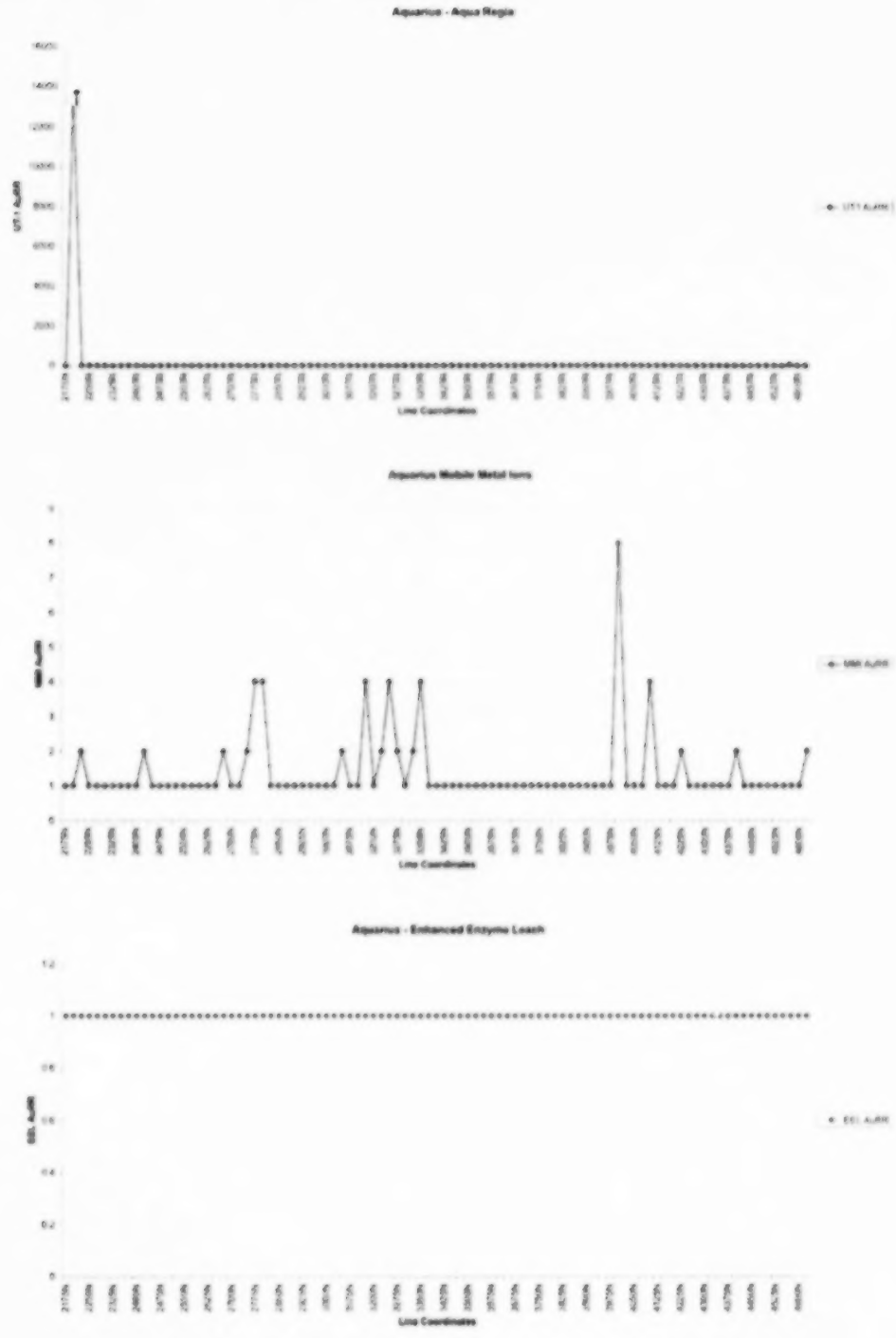

Figure 3. Stacked geochemical profiles for gold response ratios (AuRR) from aqua regia (UT-1), mobile metal ions (MMI) and enhanced enzyme leach (EEL) analyses, Aquarius transect.

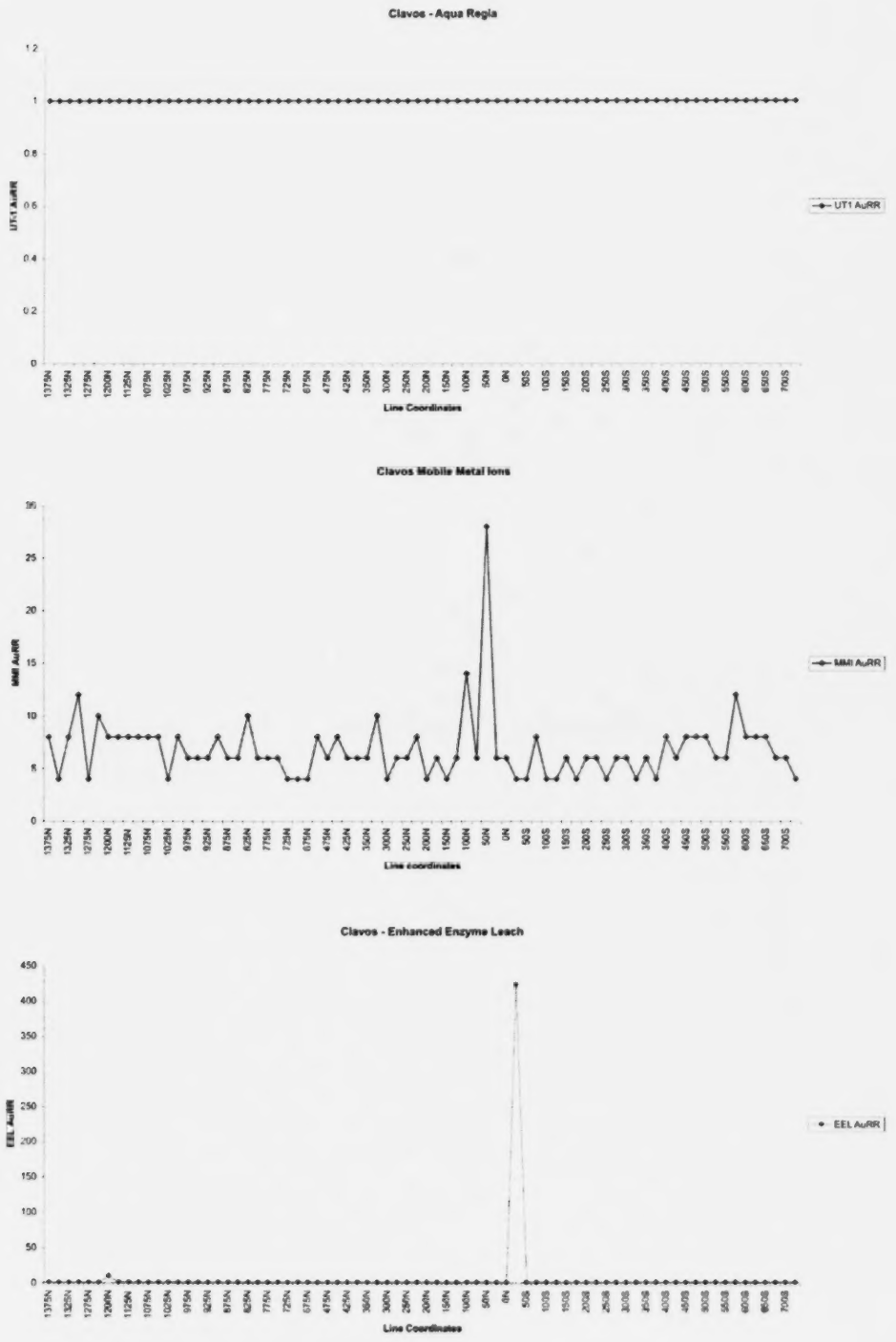

Figure 4. Stacked geochemical profiles for gold response ratios (AuRR) from aqua regia (UT-1), mobile metal ions (MMI) and enhanced enzyme leach (EEL) analyses, Clavos transect.

Hislop Transect Profile Line 0W

The Hislop transect, at 6000 m, is the longest transect, sampled during the Discover Abitibi Initiative. The magnitude of the geochemical responses and the number of the samples responding in each of the 3 data types (*see* Figure 5) are significant along this line.

The MMI data, with AuRR values ranging from 1 to 148, record 3 areas of variable responses along the transect. These include a single-sample high-contrast response of 148 at 1900N; a low-contrast Au response between 75S and 175S comprising 2 samples with AuRR values of 10 and 16, respectively; and a broad zone of low- to moderate-contrast (12 to 42) between 375S and 550S. Each of these responses documents narrow zones (<25 m) and wider zones (up to 175 m) that are reflecting bedrock-hosted gold mineralization.

The EEL data have a range of AuRR values of 1 to 135 surpassing that for the MMI data. However, the elevated responses are single sample, widely separated anomalies and are documented from the following stations: 450S (351 AuRR), 1575S (20 AuRR) and 2975S (16 AuRR). The responses at 1575S and 2975S are low-contrast anomalies and the AuRR value of 351 at station 450S has an associated low-contrast value of 16 with it. The station 450S would be considered to be the best target in the MMI data on this line.

The UT-1 data have a large number of multi-sample high-contrast responses and some of these correspond with the elevated MMI and EEL anomalies. These are

1. a single sample AuRR response of 85 at 1900N (AuRR MMI=148 at this location), and
2. a three-sample anomaly with AuRR ranging from 122 to 576 between 400 and 450S (corresponds with MMI response of 42 and EEL response of 351).

Both of these responses should be considered as follow-up exploration targets.

There are a total of 10 "new" aqua regia AuRR anomalies that have no correspondence with either MMI or EEL data. These include

	Samples	AuRR values
1.	25N-1	93
2.	250N-1	33
3.	1550N-1	1724
4.	between 2450N and 2575N-5	44–11 400
5.	between 2725N and 2850N-4	78–1532
6.	between 2950N to 3000N-3	230–1596
7.	between 150S to 175S-2	188–368
8.	between 675S to 750S-4	34–290
9.	1025S-1	162
10.	1300S-1 sample	20

The multi sample high-contrast responses such as those in 4, 5 and 6 are very high responses that should be followed up with geophysical and additional geochemical surveys. However, the caveat is that these responses are most likely related to a reworked glacial train of gold responses and so care should be taken to determine the glacial history of this area before additional geochemical follow-up is attempted. This is substantiated by the lack of either MMI or EEL coincident responses.

It is possible that the Hislop transect has cut through or at an oblique angle to the trend of a glacially dispersed Au train and hence the multiplicity of anomalous responses.

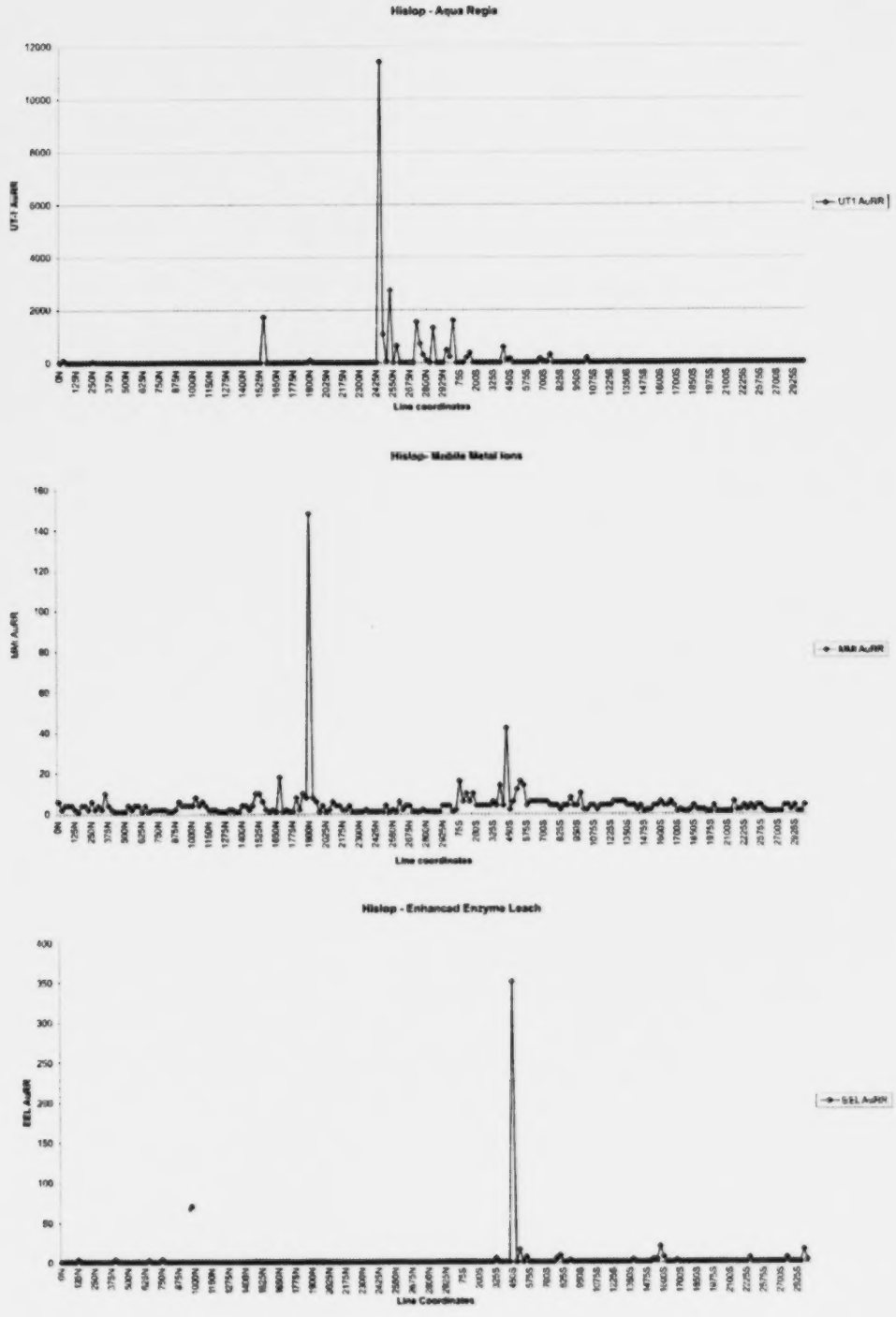

Figure 5. Stacked geochemical profiles for gold response ratios (AuRR) from aqua regia (UT-1), mobile metal ions (MMI) and enhanced enzyme leach (EEL) analyses, Hislop transect.

Holmer Transect Profile Line 48E

The responses obtained from sampling along this transect are generally subdued single-sample anomalies (*see* Figure 6). The range in MMI AuRR ranges from 1 to 18 in MMI within a broad zone of low-contrast responses between 8300N and 8650N. The EEL data reflect a similar magnitude of response with 2 samples having AuRR of 25 and 18 at 6650N and 6700N, respectively. Neither of these responses have correspondence with MMI anomalies.

Similarly, the UT-1 data show 2 high-contrast anomalous responses of 600 at 6600N and 55 at 6400N. There is no direct correspondence between these responses and either the MMI or EEL although the MMI AuRR=600 station occurs adjacent to the EEL AuRR=25.

Matachewan Transect Profile Line 40E

The most significant of MMI, EEL and UT-1 are documented from the Matachewan transect (*see* Figure 7). This is based on the magnitude of the responses, the number of samples comprising each anomaly and the coincidence between each of the analytical protocols.

The MMI responses are best developed in two areas separated by 400 m of nonresponsive soil. Overall the MMI AuRR ranges from 1 to 1120 in MMI.

The first of these responses occurs between 600N and 875N with 11 samples having a range of AuRR=10 to 548. The second site occurs between 200N and 400N and is characterized by 9 samples ranging in AuRR from 6 to 1120.

The EEL data is also marked by 2 areas of significantly elevated Au responses but the morphology of the response is erratic with many low-contrast responses interspersed with the high-contrast responses. These 2 areas are basically coincident with the MMI anomalies. They are located between 600N and 875N and are based on the response from 6 samples. The second area occurs between 200N and 400N with AuRR varying between 1 and 524 for 6 samples.

The UT-1 Au response can be described as extensive. It is a very broad, high-contrast feature that encapsulates both the MMI and EEL anomalies. The anomaly extends between 475N and 1500N and comprises low- to high-contrast responses between 1 and 2212 times background. The "core" area of this response extends between 650N and 900N with AuRR varying between 25 and 2212. A second core response occurs between 200N and 400N with AuRR ranging from 32 to 8000. These two core responses correspond to MMI and EEL anomalies.

As such, this area needs to be given the highest priority for follow-up. The same caveat offered for the Hislop line and the very high-contrast AuRR observed there. That is, the strong UT-1 responses are probably reflecting a glacially dispersed gold train and care needs to be taken to delineate glacial advances in the area. This may be assisted by expanding the soil sampling coverage on either side of the Matachewan transect and also implementing geophysical surveys.

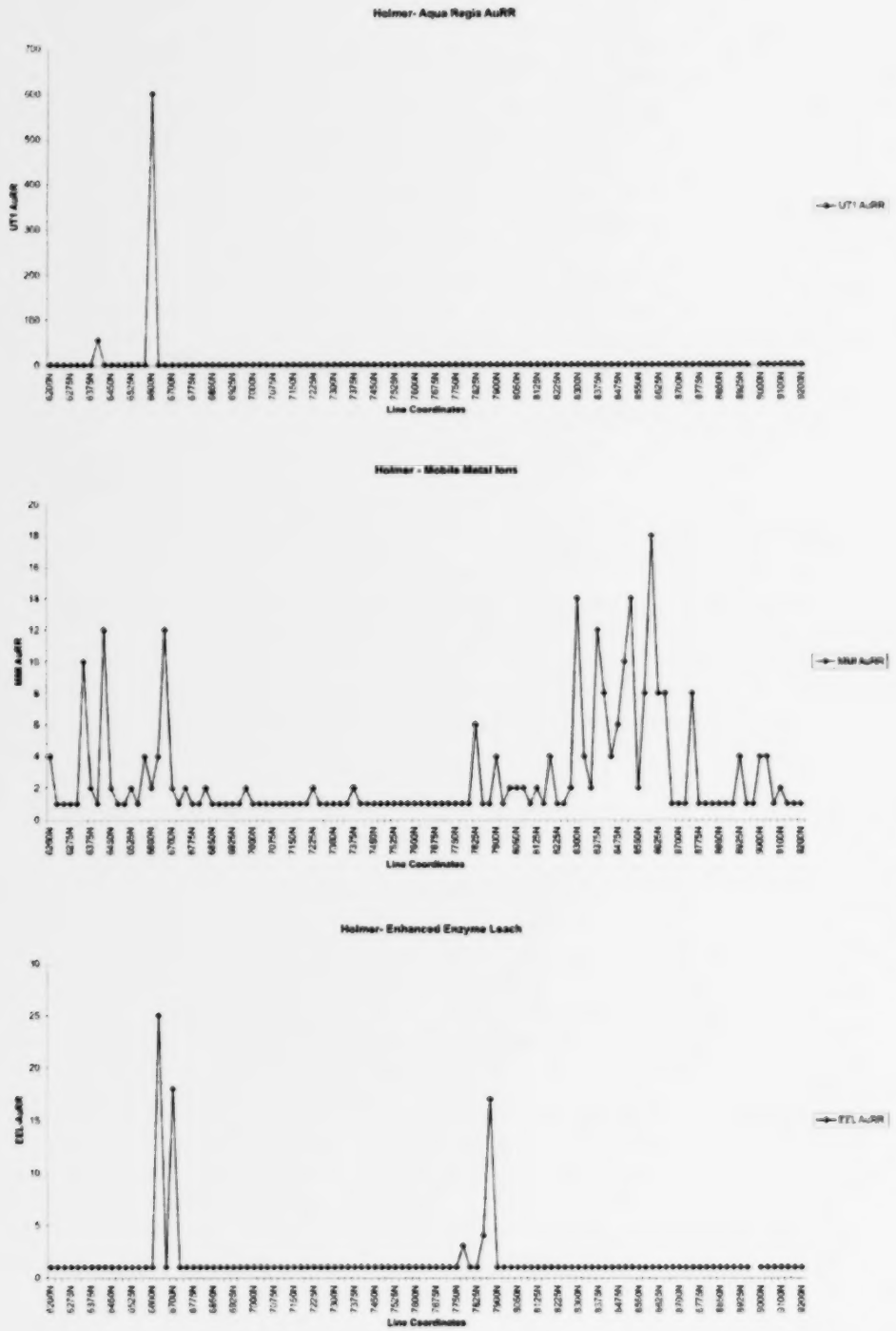

Figure 6. Stacked geochemical profiles for gold response ratios (AuRR) from aqua regia (UT-1), mobile metal ions (MMI) and enhanced enzyme leach (EEL) analyses, Holmer transect.

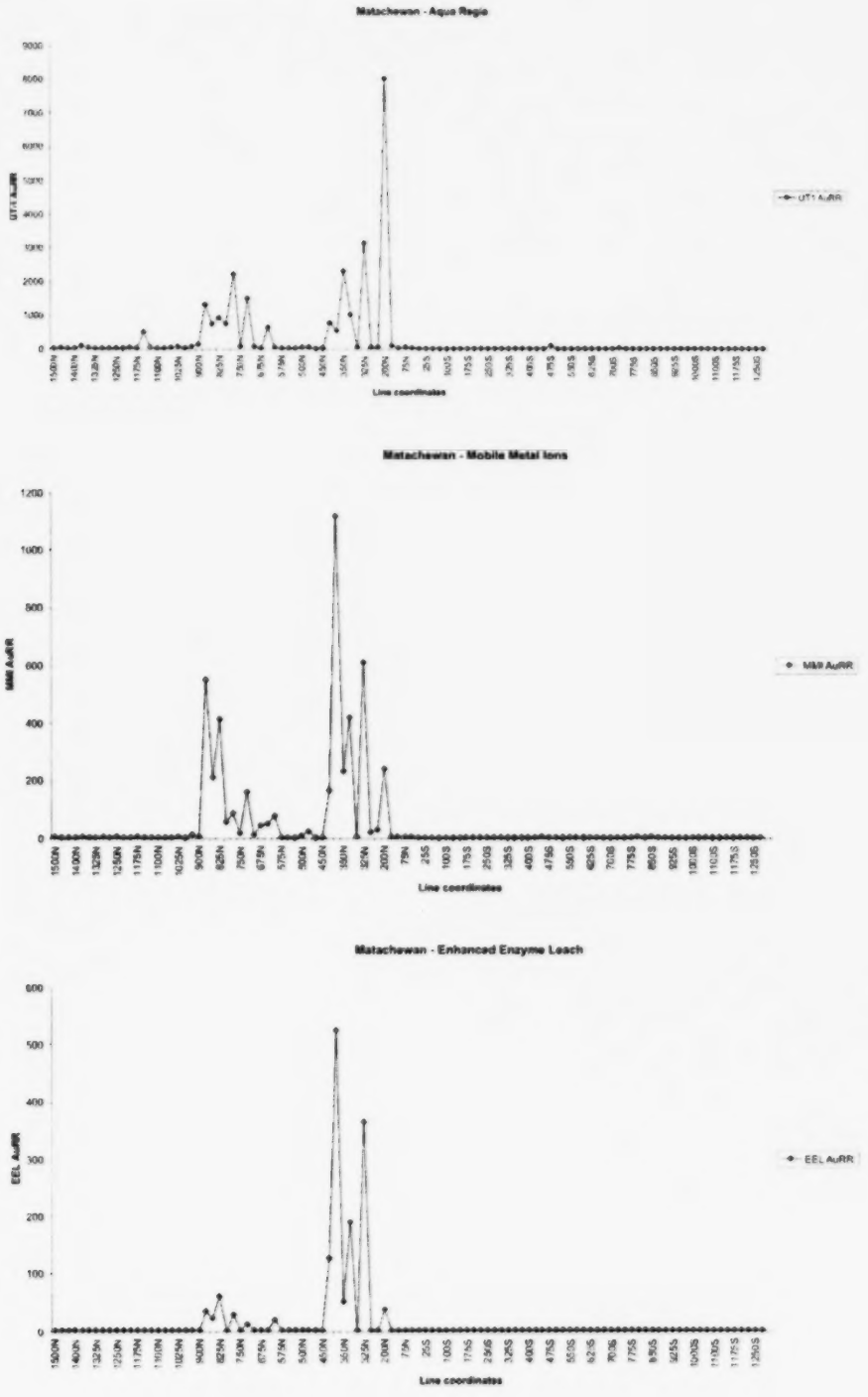

Figure 7. Stacked geochemical profiles for gold response ratios (AuRR) from aqua regia (UT-1), mobile metal ions (MMI) and enhanced enzyme leach (EEL) analyses, Matachewan transect.

Michaud Transect Profile Line 101E

The MMI data from the Michaud transect comprises low-contrast responses between 10 900N and 11 275N (*see* Figure 8). This area has peak AuRR of 12 and 24 and is considered to be a weak response. The EEL responses are significantly higher than those for MMI, although they are single-sample anomalies. These include a sample with a value of 137 at 11250N that corresponds approximately to the MMI AuRR range 12-24 anomaly. A second EEL anomaly, with a value of 128, occurs at 10 400N in isolation on the transect.

The UT-1 results document 3 separate single-sample anomalous responses and one multi-sample anomaly. The multi-sample response occurs between 9050N and 9250N with a range of AuRR=16 to 41 in 7 of 9 samples collected along this 200 m portion of the transect. This is a low- to moderate-contrast response. The 3 single-sample anomalies occur at 11 500N (26AuRR), 11 225N (20AuRR) and 10 350N (391AuRR).

Newmont Transect Profile Line 0W

Perhaps the least interesting of the transects in terms of MMI, EEL and UT-1 results is the Newmont transect (*see* Figure 9). The range in AuRR within the MMI database is 1 to 10 and this is considered random background variation without a significant response or pattern of response. Similar low ranges in AuRR were obtained for the EEL and UT-1 data.

Ogden Transect Profile Line 0W

The Ogden transect is marked by some high-contrast responses for each of the analytical protocols (*see* Figure 10). Unfortunately, it can be demonstrated these responses are the result of anthropogenic contamination related to mine site ore and/or waste piles through which the sampling transect was established. Table 1 below summarizes the coincident anomalies for MMI, EEL and UT-1 for contaminated sites and also a uncontaminated site marked by coincident anomalous AuRR.

Table 1. Summary of anthropogenic contaminated responses on the Ogden transect, Line 0W.

Location	MMI AuRR	EEL AuRR	UT-1 AuRR	Cause
50S	518	193	1368	mine waste
75S	158	114	138	mine waste
200S	256	144	250	no waste
2050S	32	21	8	no waste
75N	476	137	264	mine waste

The stronger aqua regia digest reflects the higher AuRR at 50S. Interestingly, the higher MMI AuRR of 158 versus 138 at 75S and 476 versus 264 at 75N indicate that the MMI extraction has an equal or greater ability to extract elevated concentrations of gold from mine waste piles. The reason for this may be the oxidized nature of the mineralized material at surface and the form of the gold metal subsequent to oxidation.

There is a single high-contrast response ratio documented from 200S where an MMI AuRR of 256, an EEL AuRR of 144 and an UT-1 AuRR of 250 is documented. Generally, the responses on the Ogden transect are low-contrast.

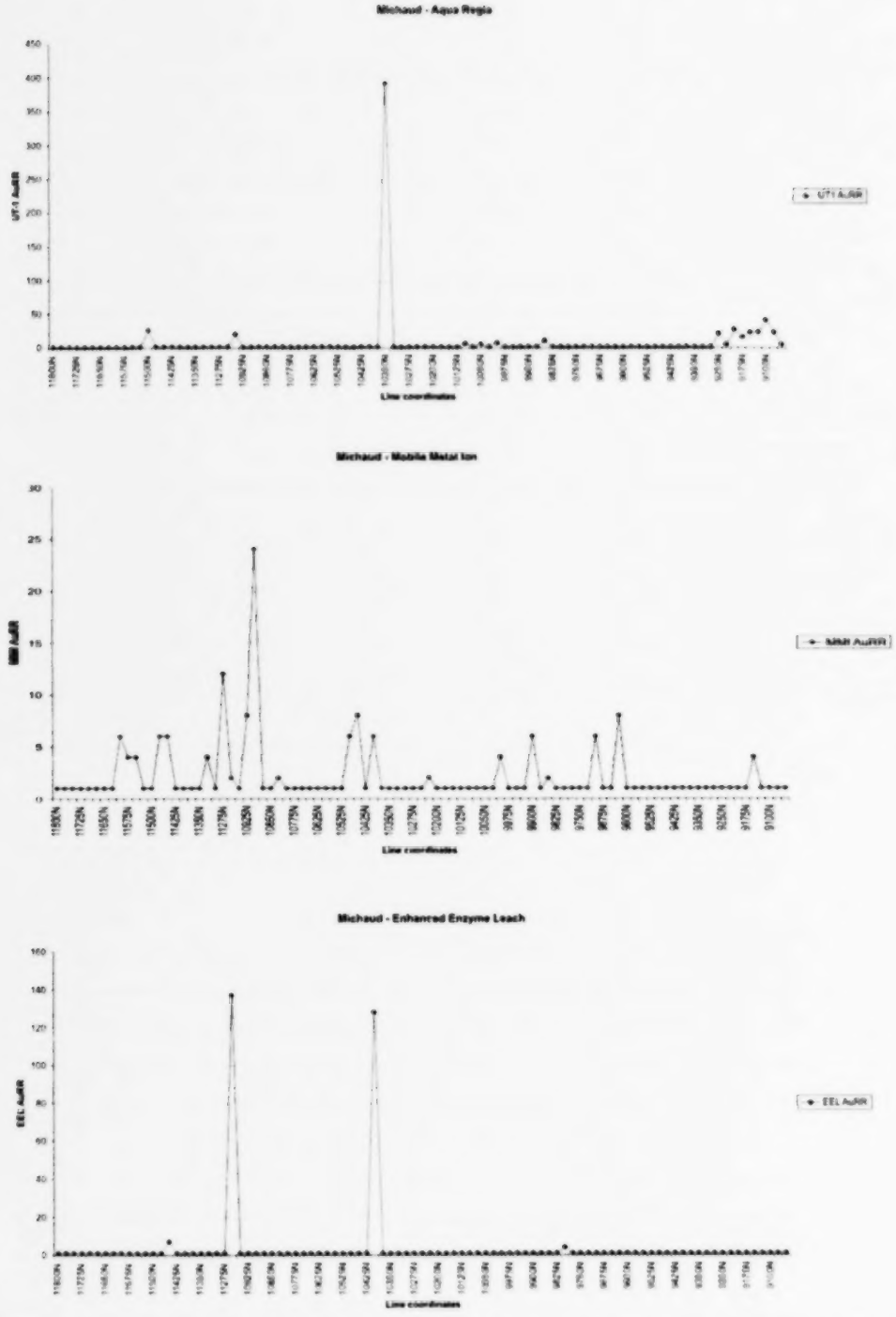

Figure 8. Stacked geochemical profiles for gold response ratios (AuRR) from aqua regia (UT-1), mobile metal ions (MMI) and enhanced enzyme leach (EEL) analyses, Michaud transect.

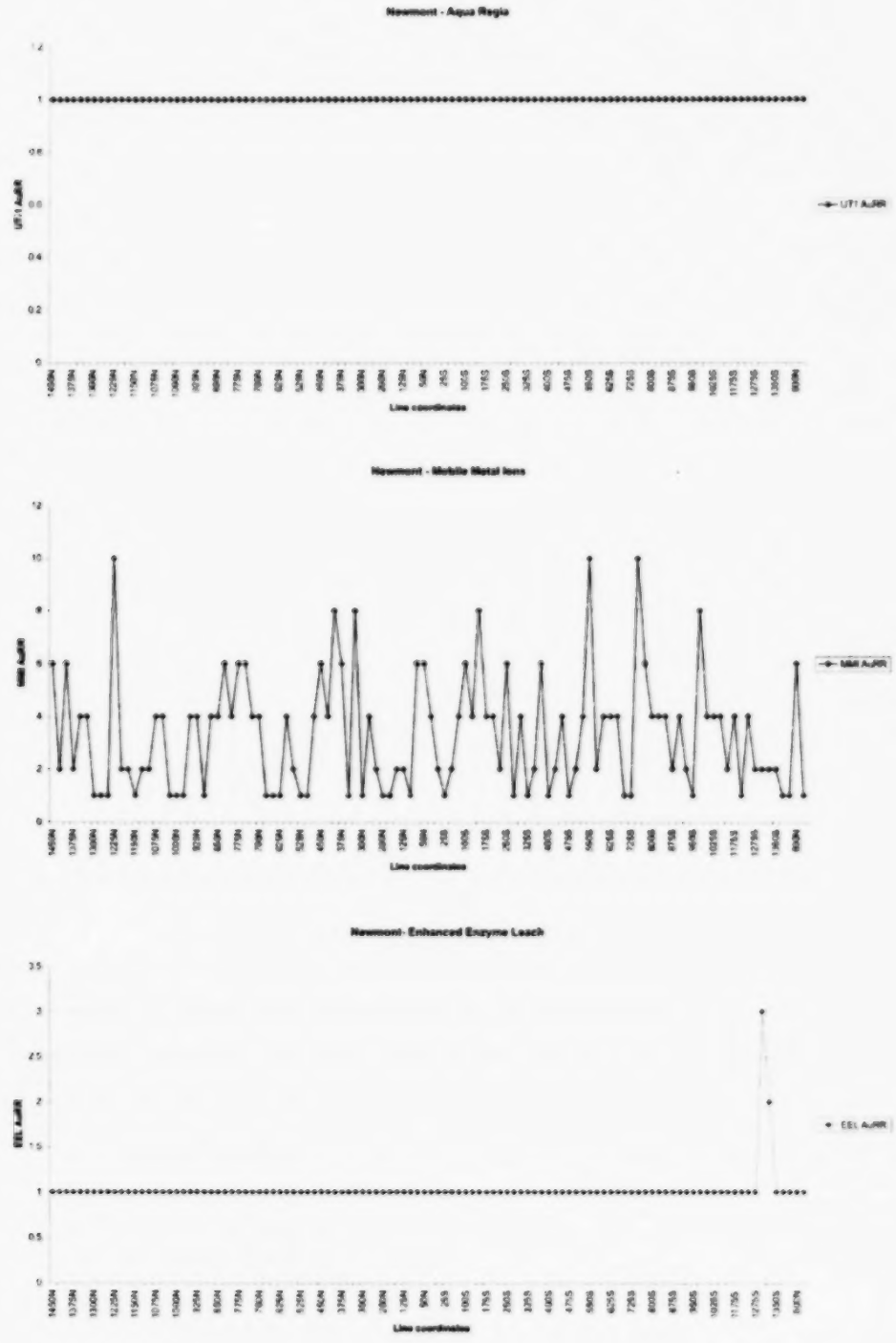

Figure 9. Stacked geochemical profiles for gold response ratios (AuRR) from aqua regia (UT-1), mobile metal ions (MMI) and enhanced enzyme leach (EEL) analyses, Newmont transect.

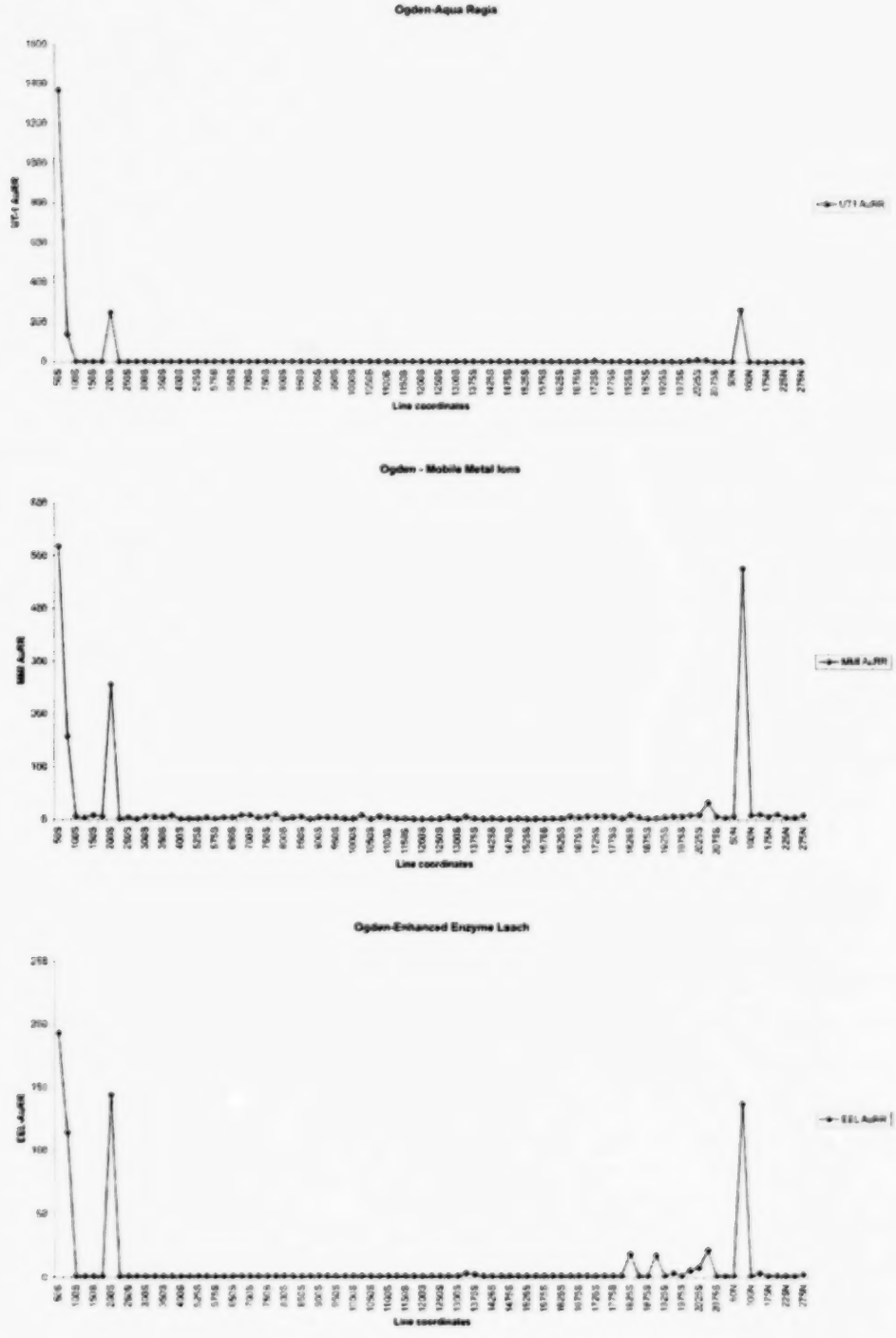

Figure 10. Stacked geochemical profiles for gold response ratios (AuRR) from aqua regia (UT-1), mobile metal ions (MMI) and enhanced enzyme leach (EEL) analyses, Ogden transect.

Discussion

This soil geochemical survey defined anomalous responses based on all 3 analytical protocols for 5 of the 8 transects tested and for 2 methods on the others. The purpose of using 2 weak extractions was to look for coincident responses in these data and then compare and contrast these results with the stronger aqua regia digest. While coincident anomalies for 2 analytical protocols were common, true coincident anomalies for all 3 were less frequent. The Matachewan and Hislop transects have the best such responses.

The aqua regia-based digestion will only digest Au that is exposed on or in a soil particle or a free Au particle. Therefore these anomalies can also reflect erosional remnants from a distant source region that was glaciated (since the host sediments are glacial derivatives) and may not be representative of *in-situ* mineralization or mineralization that may be buried and blind. For this reason follow-up geochemical surveys would be necessary to determine whether these features are glacial in origin.

The success of the MMI and EEL extractions in defining low-to high-contrast multiple sample anomalies is a very positive development. This indicates that *bona fide* anomalies exist in the survey areas which are the manifestation of gold ions migrating from a mineralized source to near-surface soils. Follow-up surveys of these anomalies may focus on determining target depth.

The use of quality assurance and quality control samples in this survey has demonstrated their usefulness in delineating analyses that may not be reproducible and accurate and, therefore, not useful in soil geochemical surveys. This appears to be the case for UT-1 data in this study, which are reproducible at higher concentration levels, but less so at concentrations close to the detection limit.

Conclusions and Recommendations

The following conclusions are evident from this soil geochemical survey in the Timmins area.

1. The geochemical survey successfully demonstrated that both MMI and EEL methods using partial extractions of soil samples collected from the 8 transects have isolated high- to moderate- and low-contrast multiple samples Au anomalies.
2. The partial extraction data tend to be of a higher calibre based on reproducibility and accuracy than the aqua regia data.
3. The anomalies defined on the Matachewan and Hislop transects are ranked as one and two, respectively in terms of areas to follow-up.
4. On some transect, the glacially derived sediments in the survey area are marked either, by large, high-contrast Au anomalies as determined by aqua regia, or the lack thereof. It will be necessary to determine whether these anomalies are derived from a shallow mineralized source or a distant source region. Their coincidence, in some cases, with MMI and EEL anomalies may suggest near bedrock sources.
5. The anomalous responses observed in the Ogden transect data demonstrate the efficacy of aqua regia to digest gold-bearing material in soil contaminated with material from mine waste piles as compared to the ability of MMI and EEL extractions to do so. The higher MMI responses for some samples collected in this environment indicates that there are multiple forms of Au present in the mine wastes sampled, probably a result of oxidation and reaction with acidic meteoric waters.

6. Sampling materials collected for MMI, EEL and UT-1 analysis are effective and appropriate sample media for these surveys.

7. The anomalies generated by the MMI extraction are accurate and precise and are effective for prioritizing geophysical anomalies.

8. In addition to these qualities, the responses for MMI data tend to be more focussed and provide higher contrast responses than the EEL data.

The recommendations that flow from this survey are as follows:

1. Since the Mobile Metal Ion Process® does not indicate the grade of mineralization responsible for the production of an MMI anomaly nor does it indicate the depth of the source region for the anomaly, it is strongly recommended that an attempt at modelling the geological setting of the target mineralization be based on their geophysical responses with emphasis on depth to source to be undertaken prior to a diamond drill program. This exercise can greatly assist drilling when attempting to provide explanations for the geological context of geophysical and MMI anomalies.

2. Prior to additional MMI surveys, an orientation survey based on the vertical profile sampling approach to identifying high-contrast residence sites in the upper 0.5 m of the soil profile, should be undertaken in selected areas.

3. A program of QA–QC sample collection should be maintained and expanded to include internal standards for the monitoring of accuracy and reproducibility.

Acknowledgments

Watts, Griffis and McOuat Limited (WGM), in particular Mr. Joe Hinzer, President, are thanked for project management and for maintaining liaison with the Timmins Economic Development Corporation throughout the course of this project. WGM is also thanked for the construction of all figures in this report and editorial assistance. Mr. Robert Calhoun is thanked for introduction to the individual properties to be sampled in the survey and this includes access and areas of anthropogenic contamination. Tom Watkins, Monica Easton and Paula Takats of the Ontario Geological Survey are thanked for assistance with the construction of this report including editorial services, modifications to figures and assistance with populating the publication template. Sample collection was undertaken by Mr. Jake Ziehlke and Mr. Ryan Oger, Winnipeg. Their diligence under less than ideal circumstances is acknowledged.

Metric Conversion Table

Conversion from SI to Imperial			Conversion from Imperial to SI		
SI Unit	*Multiplied by*	*Gives*	*Imperial Unit*	*Multiplied by*	*Gives*
		LENGTH			
1 mm	0.039 37	inches	1 inch	**25.4**	mm
1 cm	0.393 70	inches	1 inch	**2.54**	cm
1 m	3.280 84	feet	1 foot	**0.304 8**	m
1 m	0.049 709	chains	1 chain	20.116 8	m
1 km	0.621 371	miles (statute)	1 mile (statute)	**1.609 344**	km
		AREA			
1 cm^2	0.155 0	square inches	1 square inch	**6.451 6**	cm^2
1 m^2	10.763 9	square feet	1 square foot	**0.092 903 04**	m^2
1 km^2	0.386 10	square miles	1 square mile	2.589 988	km^2
1 ha	2.471 054	acres	1 acre	0.404 685 6	ha
		VOLUME			
1 cm^3	0.061 023	cubic inches	1 cubic inch	**16.387 064**	cm^3
1 m^3	35.314 7	cubic feet	1 cubic foot	0.028 316 85	m^3
1 m^3	1.307 951	cubic yards	1 cubic yard	0.764 554 86	m^3
		CAPACITY			
1 L	1.759 755	pints	1 pint	0.568 261	L
1 L	0.879 877	quarts	1 quart	1.136 522	L
1 L	0.219 969	gallons	1 gallon	**4.546 090**	L
		MASS			
1 g	0.035 273 962	ounces (avdp)	1 ounce (avdp)	28.349 523	g
1 g	0.032 150 747	ounces (troy)	1 ounce (troy)	**31.103 476 8**	g
1 kg	2.204 622 6	pounds (avdp)	1 pound (avdp)	**0.453 592 37**	kg
1 kg	0.001 102 3	tons (short)	1 ton (short)	**907.184 74**	kg
1 t	1.102 311 3	tons (short)	1 ton (short)	**0.907 184 74**	t
1 kg	0.000 984 21	tons (long)	1 ton (long)	**1016.046 908 8**	kg
1 t	0.984 206 5	tons (long)	1 ton (long)	**1.016 046 90**	t
		CONCENTRATION			
1 g/t	0.029 166 6	ounce (troy)/ ton (short)	1 ounce (troy)/ ton (short)	34.285 714 2	g/t
1 g/t	0.583 333 33	pennyweights/ ton (short)	1 pennyweight/ ton (short)	1.714 285 7	g/t

OTHER USEFUL CONVERSION FACTORS

	Multiplied by	
1 ounce (troy) per ton (short)	31.103 477	grams per ton (short)
1 gram per ton (short)	0.032 151	ounces (troy) per ton (short)
1 ounce (troy) per ton (short)	20.0	pennyweights per ton (short)
1 pennyweight per ton (short)	0.05	ounces (troy) per ton (short)

Note: Conversion factors which are in bold type are exact. The conversion factors have been taken from or have been derived from factors given in the Metric Practice Guide for the Canadian Mining and Metallurgical Industries, published by the Mining Association of Canada in co-operation with the Coal Association of Canada.

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